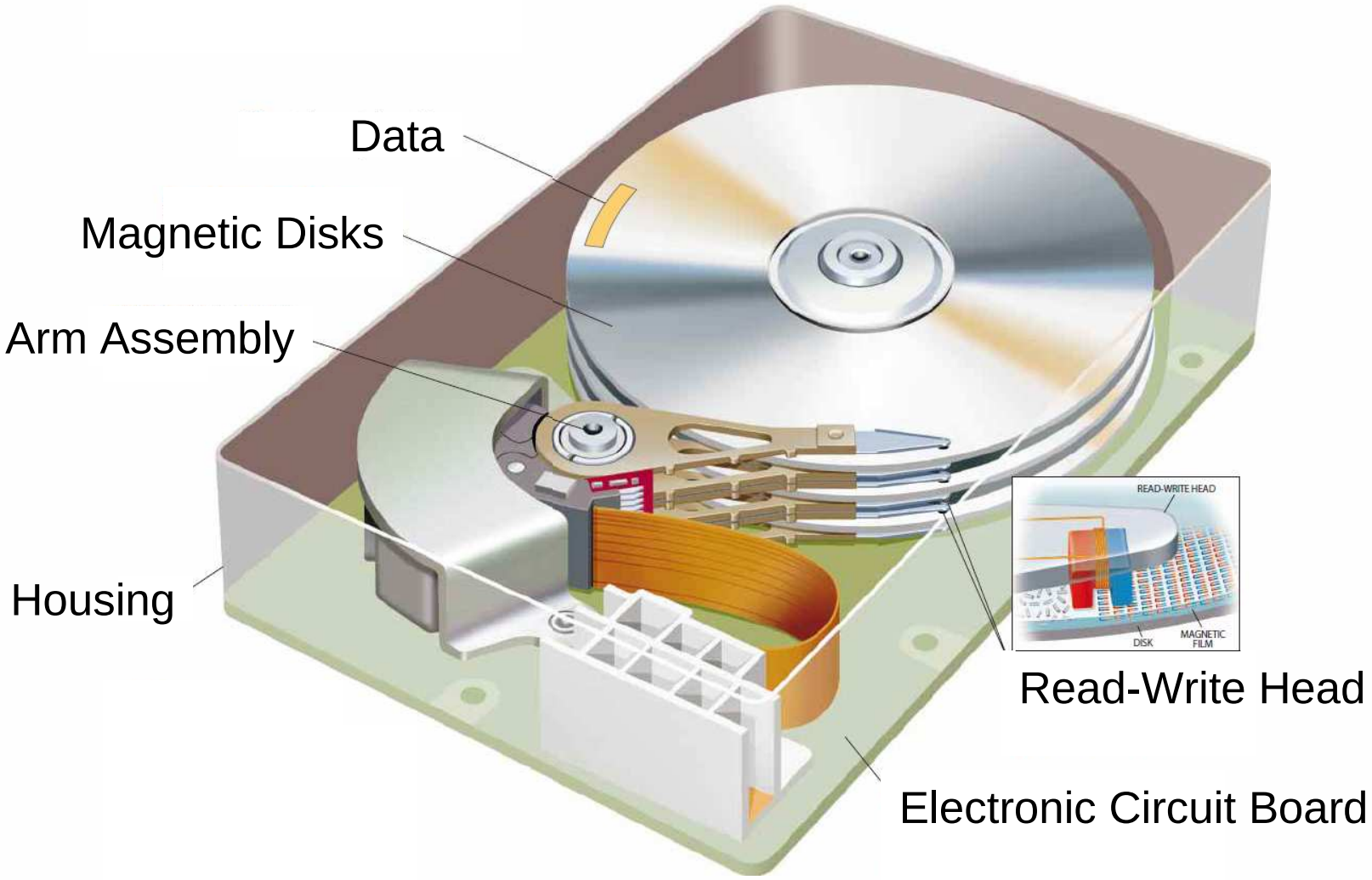
# Hard Drive Basics

- Inside a Hard Disk Drive

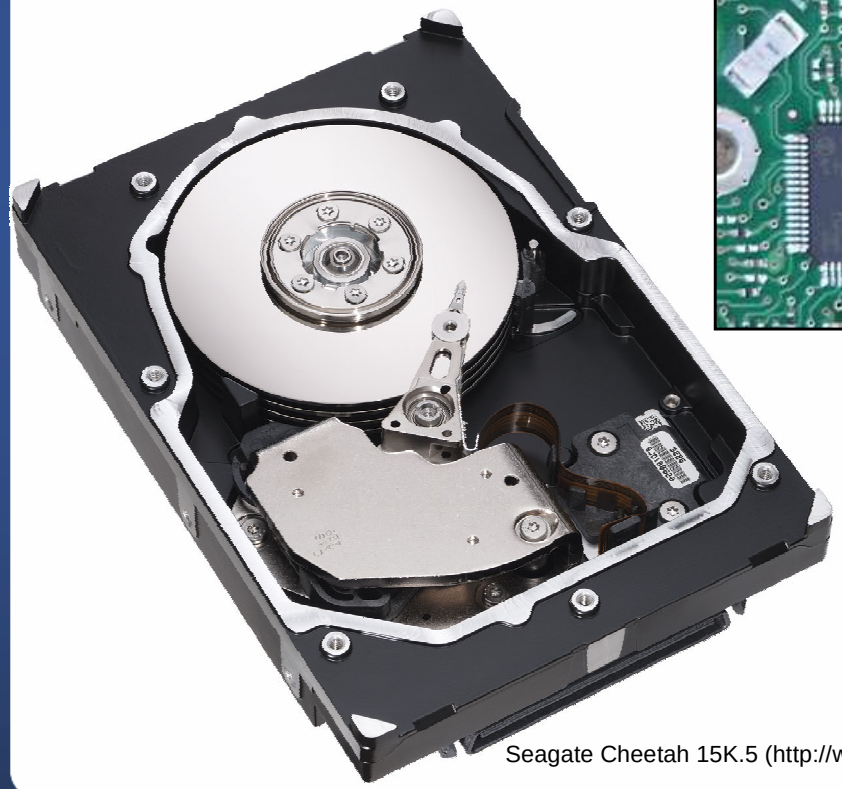



Toigo, *Avoiding a Data Crunch*, Scientific American (May 2000) [Marvell Tutorial Exh. 3]

# Hard Drive Electronics

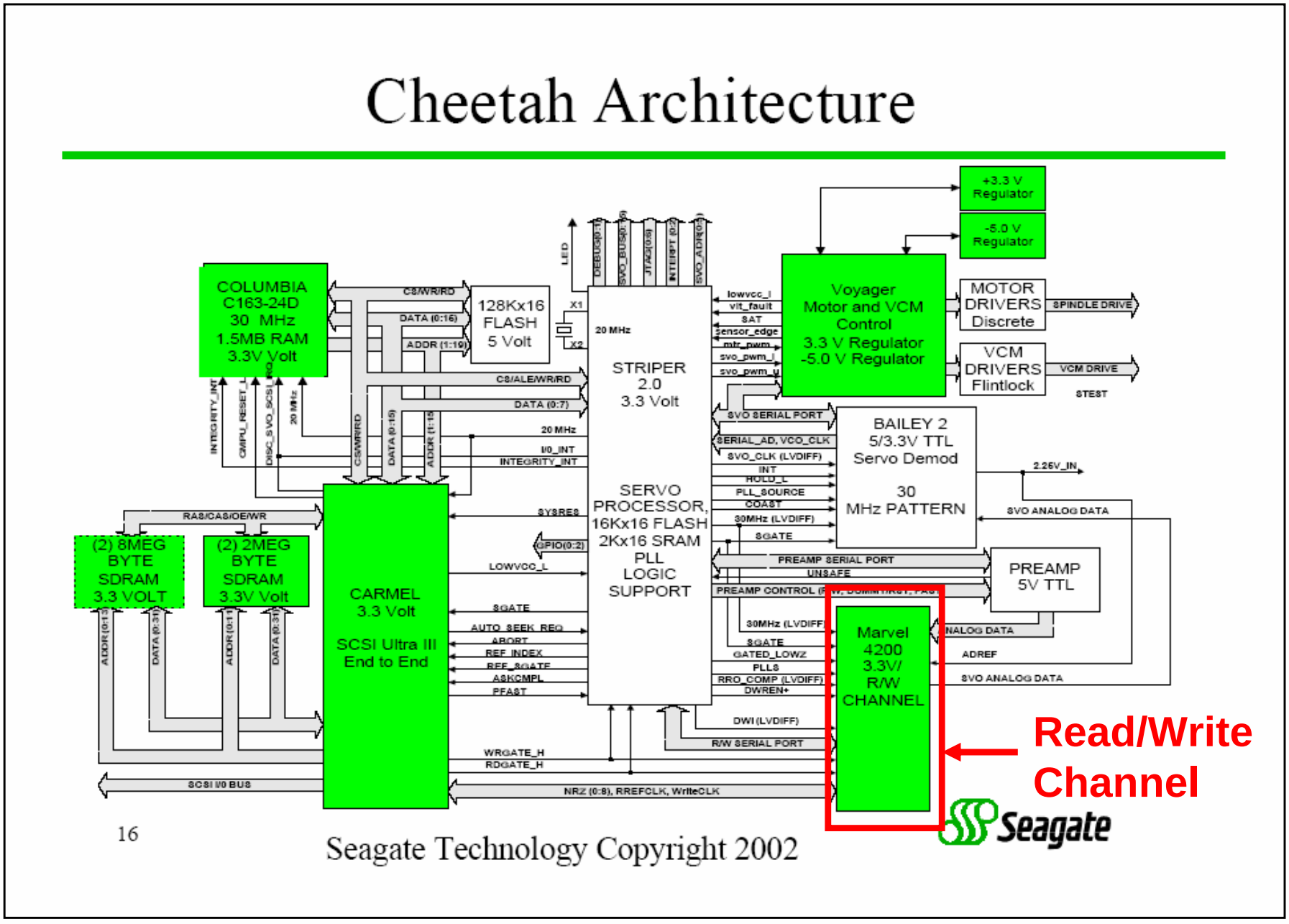
- Processors
- Controllers
- Memory
- Interfaces
- Read/Write Channel


Maxtor One Touch 4 circuit board (http://forums.seagate.com)



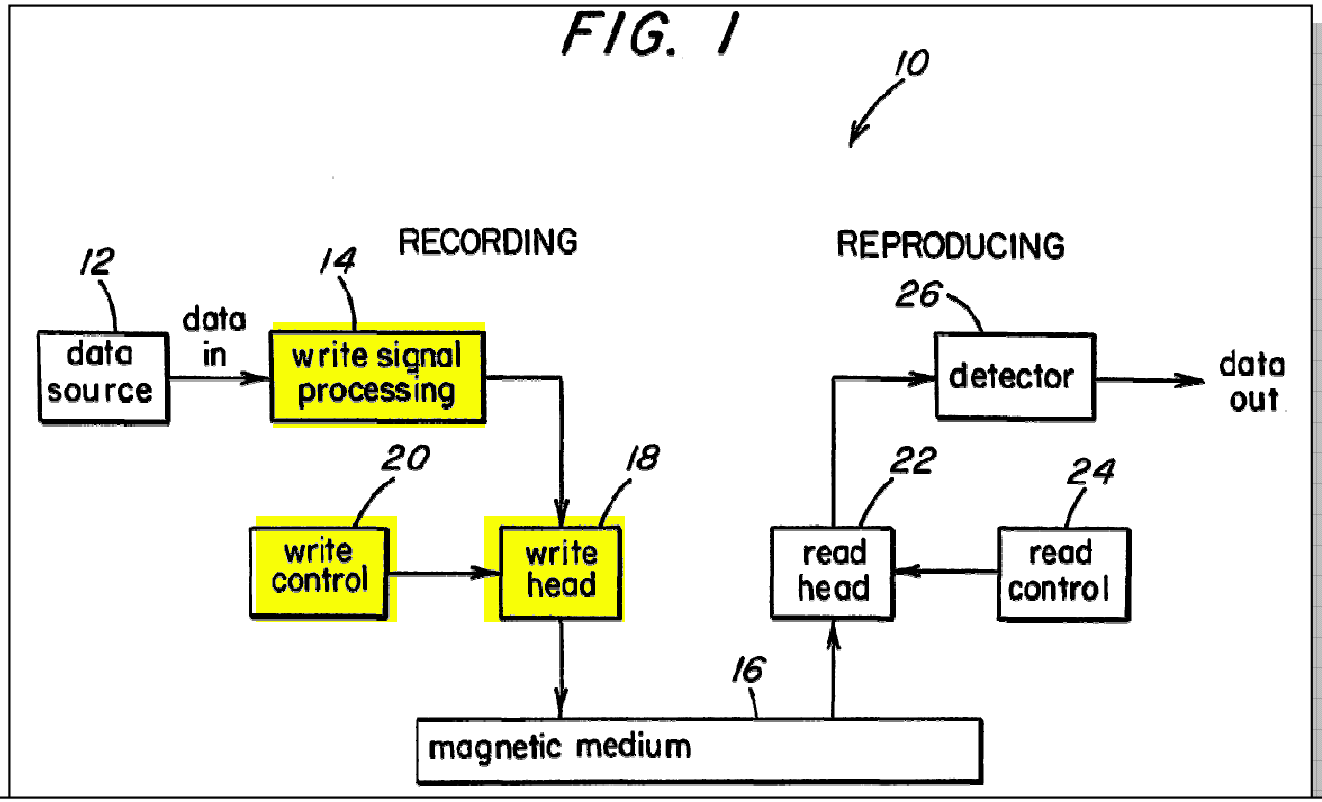
Seagate Cheetah 15K.5 (http://www.seagate.com)

# Hard Drive Electronics




Gurumurthi, ABC's of Disk Drives (University of Virginia) http://www.cs.virginia.edu/~gurumurthi/courses/HDD_Basics.ppt

# Magnetic Recording System: Writing Data

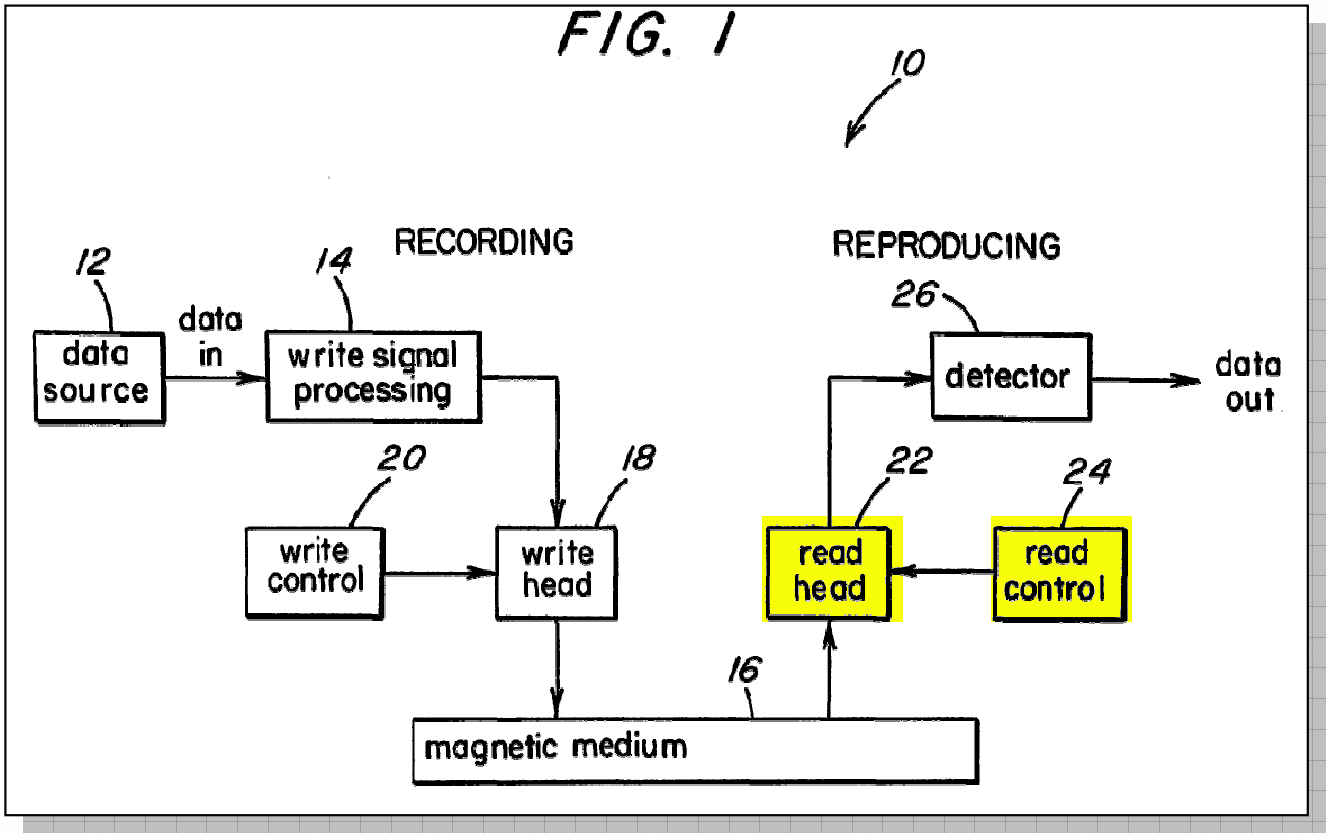



Patent Fig. 1

- "**Write head**" means "a magnetic device that writes (or stores) signals to a magnetic medium as a series of variations in the magnetic flux of the medium."
- "**Write control circuit**" means "a circuit that controls the position of the write head with respect to a magnetic medium."
- "**Write signal processing circuit**" means "a circuit that converts data into signals with a format suitable for storage on a magnetic medium."

Joint Agreed Claim Terms (Dkt. 74)

# Magnetic Recording System: Reading Data

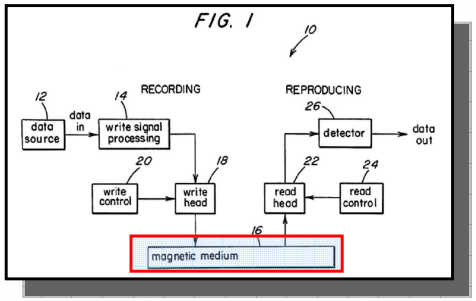



Patent Fig. 1

- "**Read head**" means "a magnetic device that reads (or retrieves) signals from a magnetic medium, that are stored on the medium as a series of variations in magnetic flux."
- "**Read control circuit**" means "a circuit that controls the position of a read head with respect to a magnetic medium."

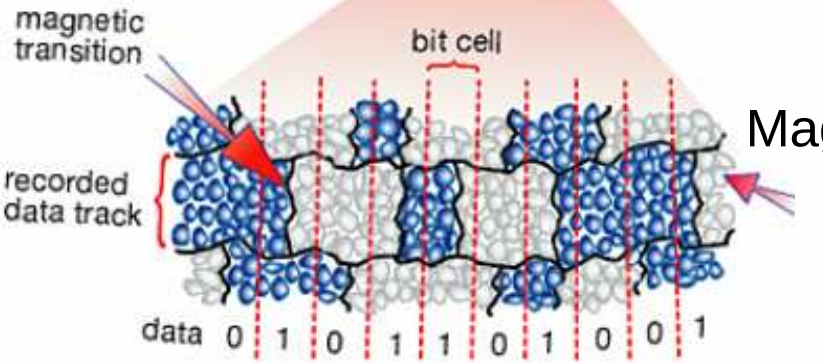
Joint Agreed Claim Terms (Dkt. 74)

# Magnetic Medium (Hard Disk)




Magnetic Disk

Data stored in tracks

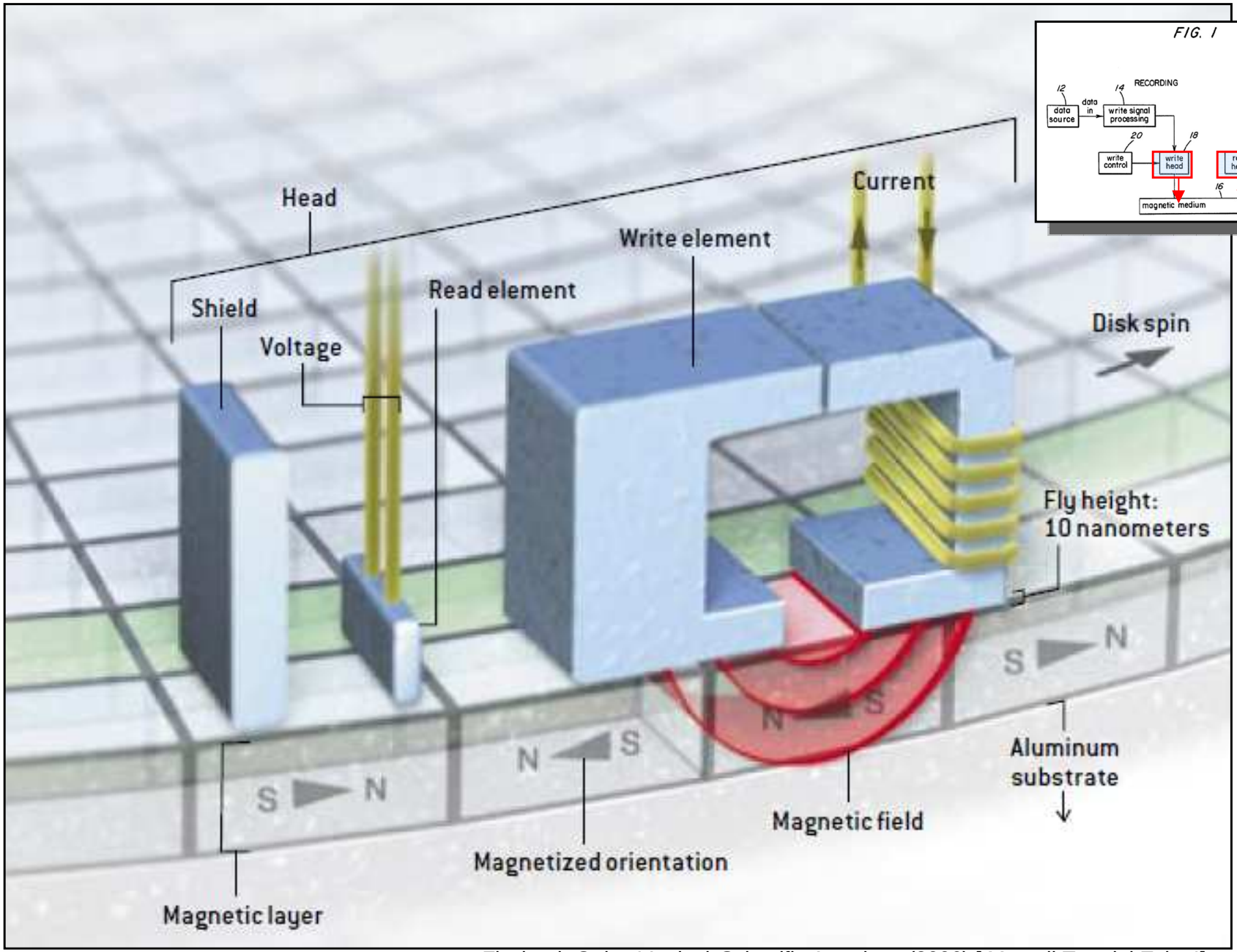



Magnetic transitions define the data:

- "1": magnetic transition
- "0": no magnetic transition

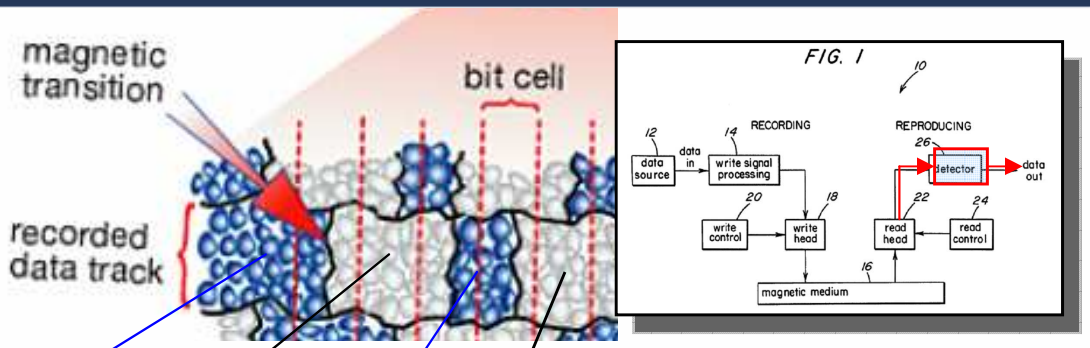
Hitachi Global Storage Technologies (2004)

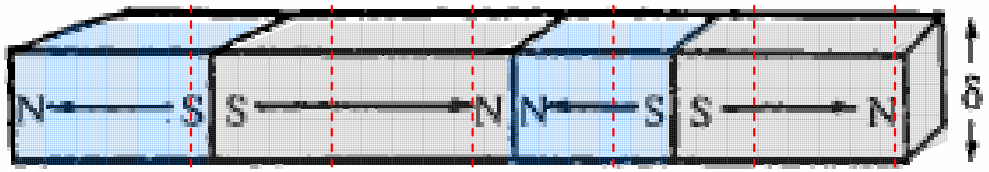
# Read/Write Head



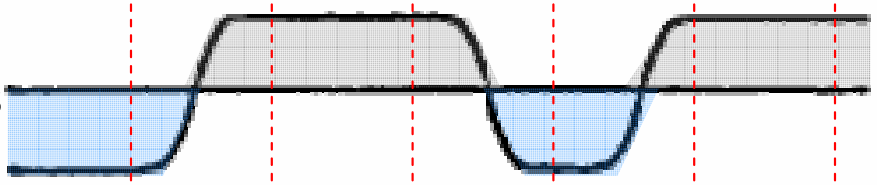

Fischetti, *Going Vertical*, Scientific American (2006) [ Marvell Tutorial Exh. 4]

# Hard Disk Read Channel

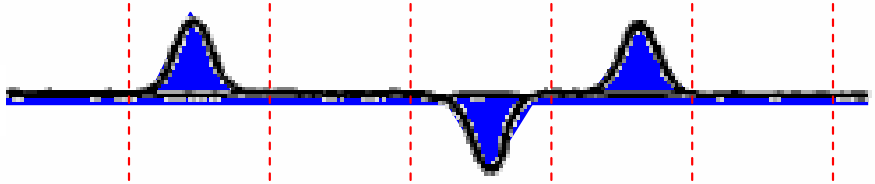



Magnetic Tracks



Magnetic Flux Changes

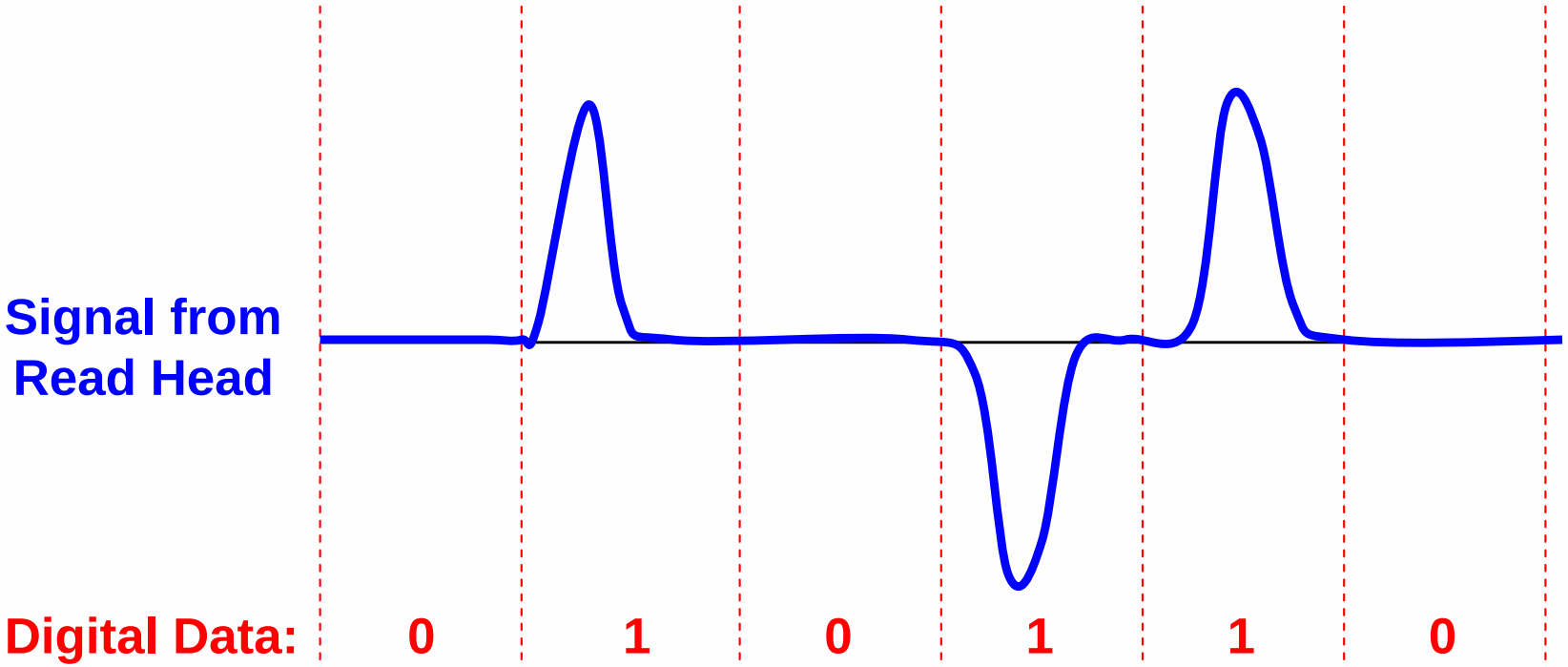


Transition Signals

Digital Data: 0 | 1 | 0 | 1 | 1 | 0

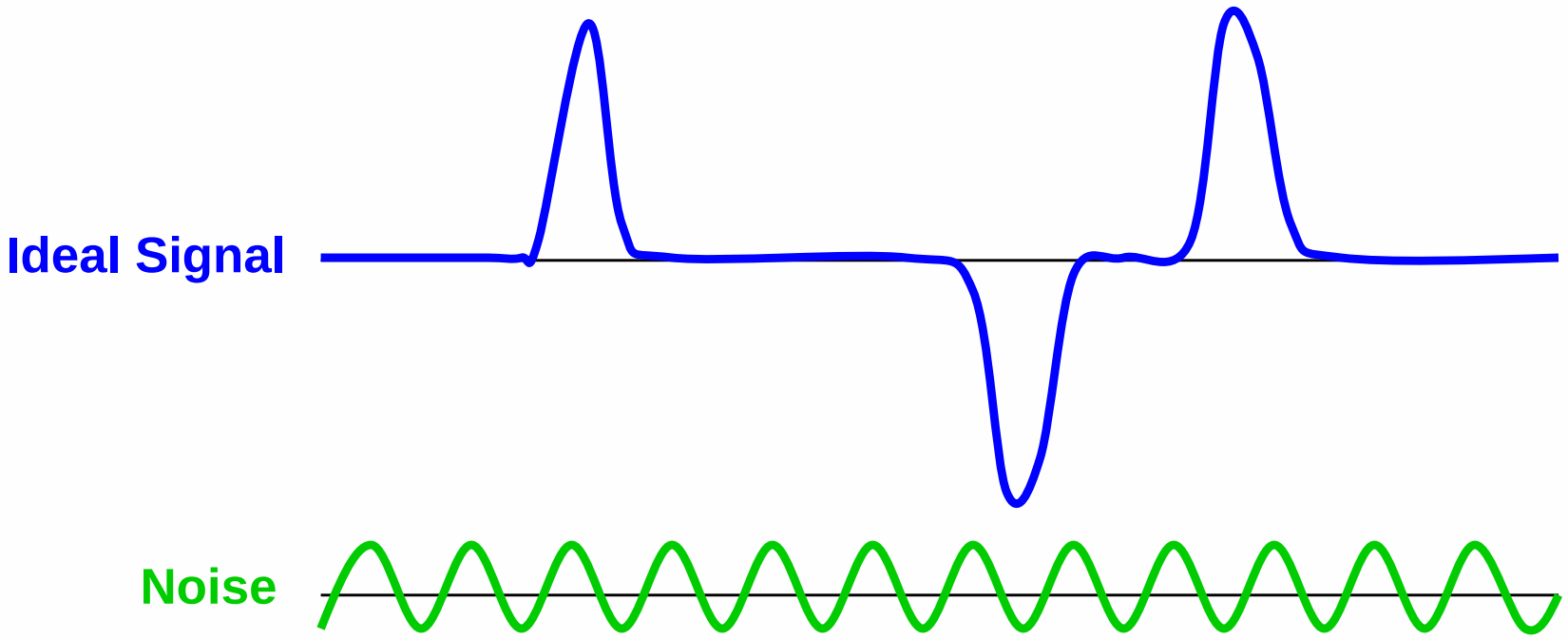
Ashar, *Magnetic Disk Drive Technology* at 45 (1997) [Marvell Tutorial Exh. 5]

# Read Signal




- Positive or negative peaks at magnetic transitions
- Data is 1 at peaks and 0 when there is no peak

# Signal and Noise

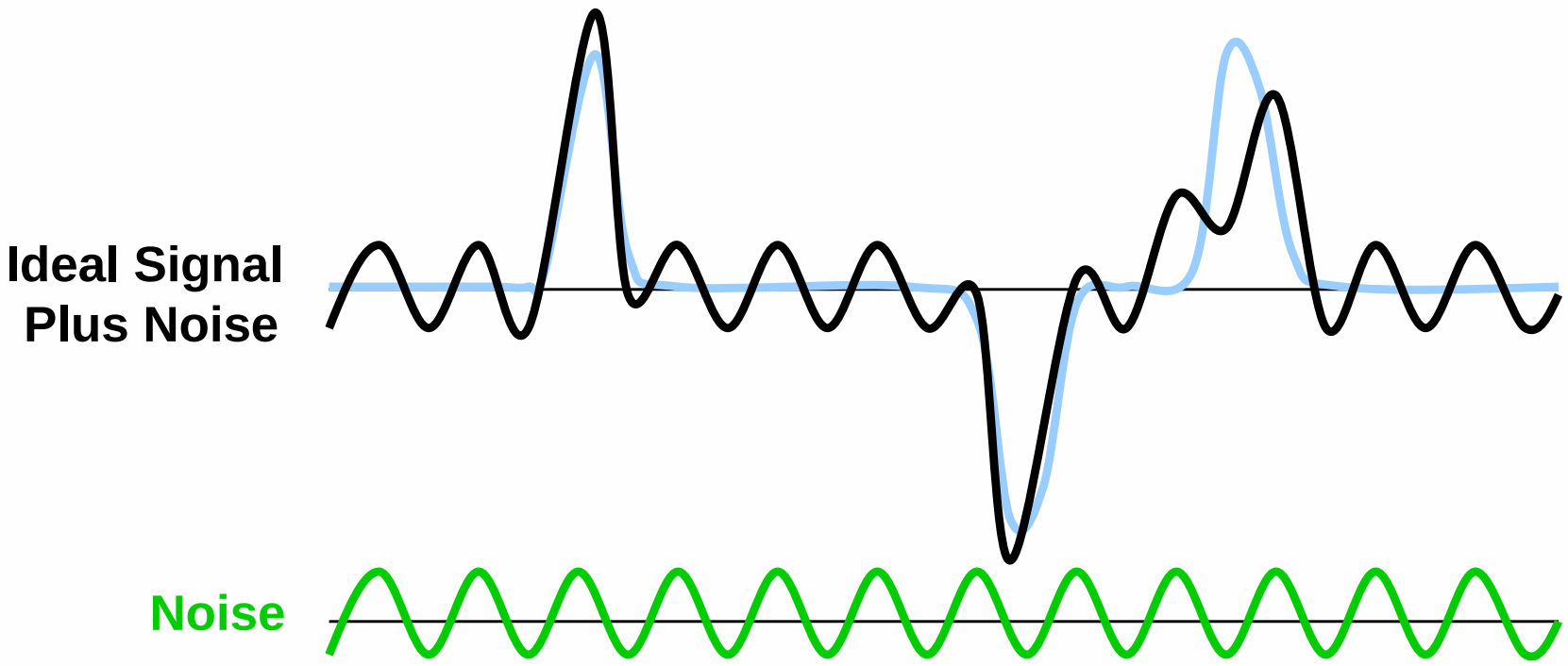



- Read signal can be distorted by noise

"Noise" is "an unwanted disturbance in a signal."

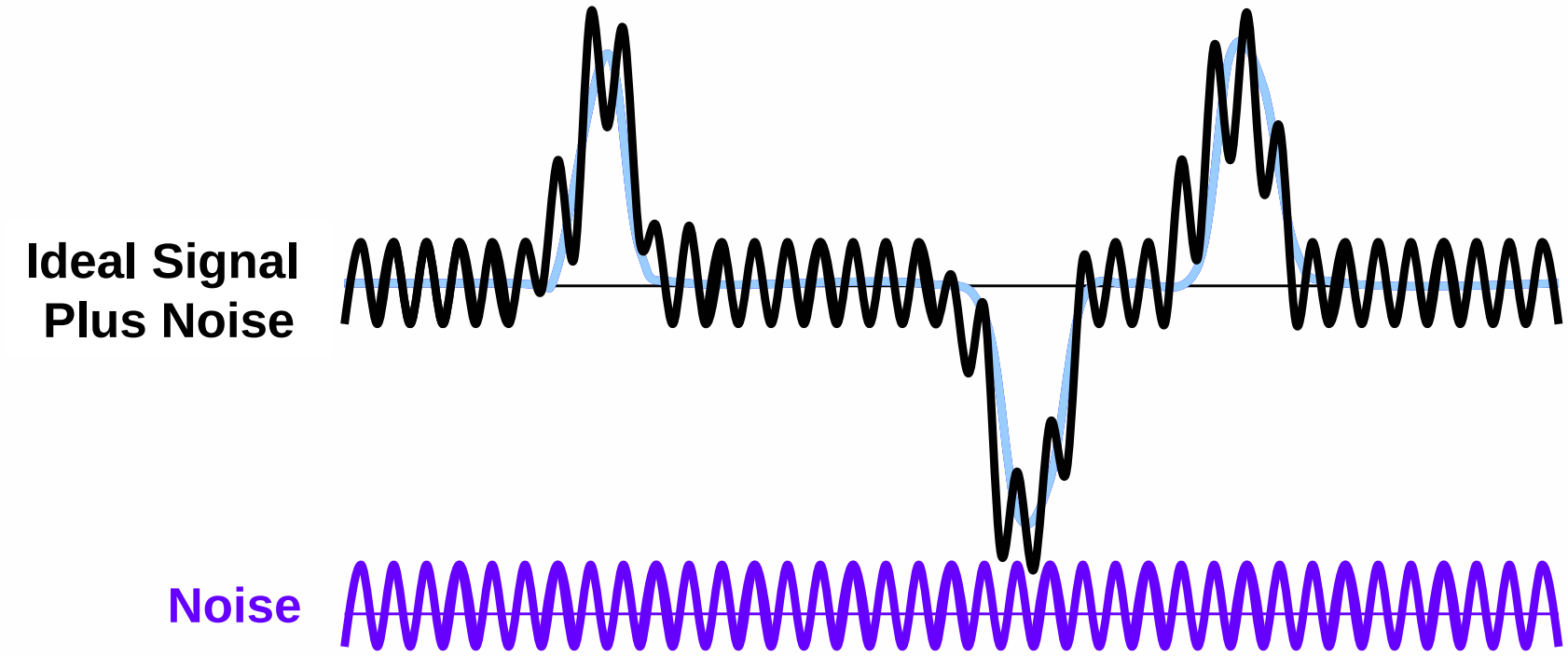
Joint Agreed Claim Terms (Dkt. 74)

# Signal and Noise



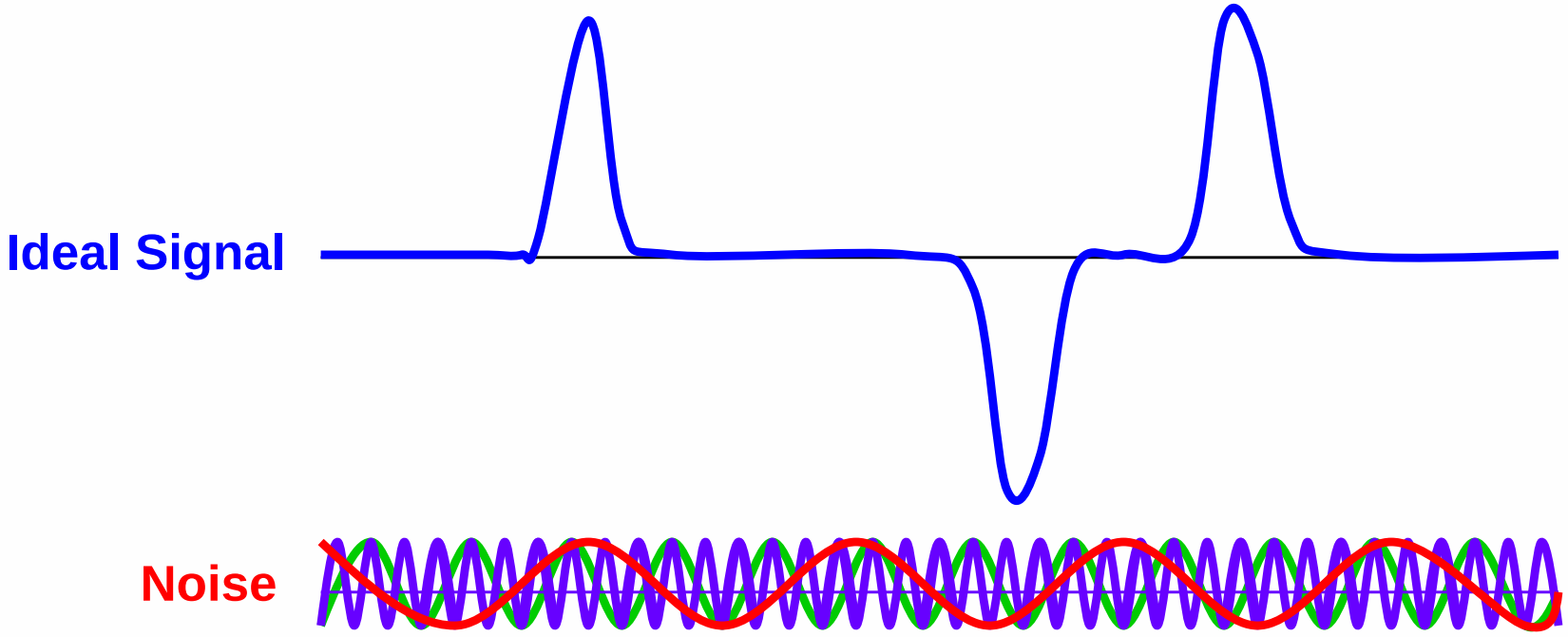

- Read signal includes noise

# Signal and Noise



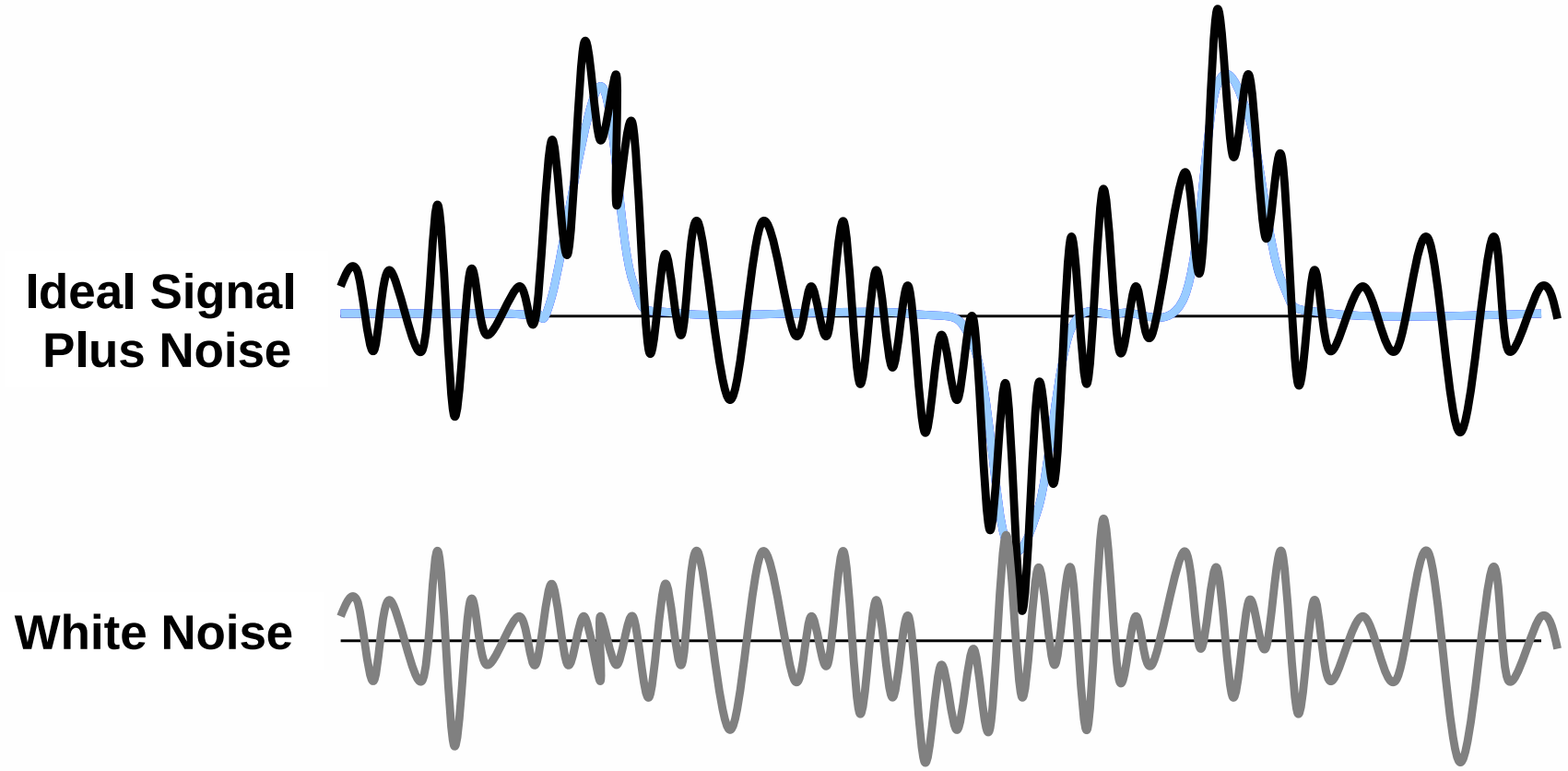

- Noise can have different characteristics

# Signal and Noise



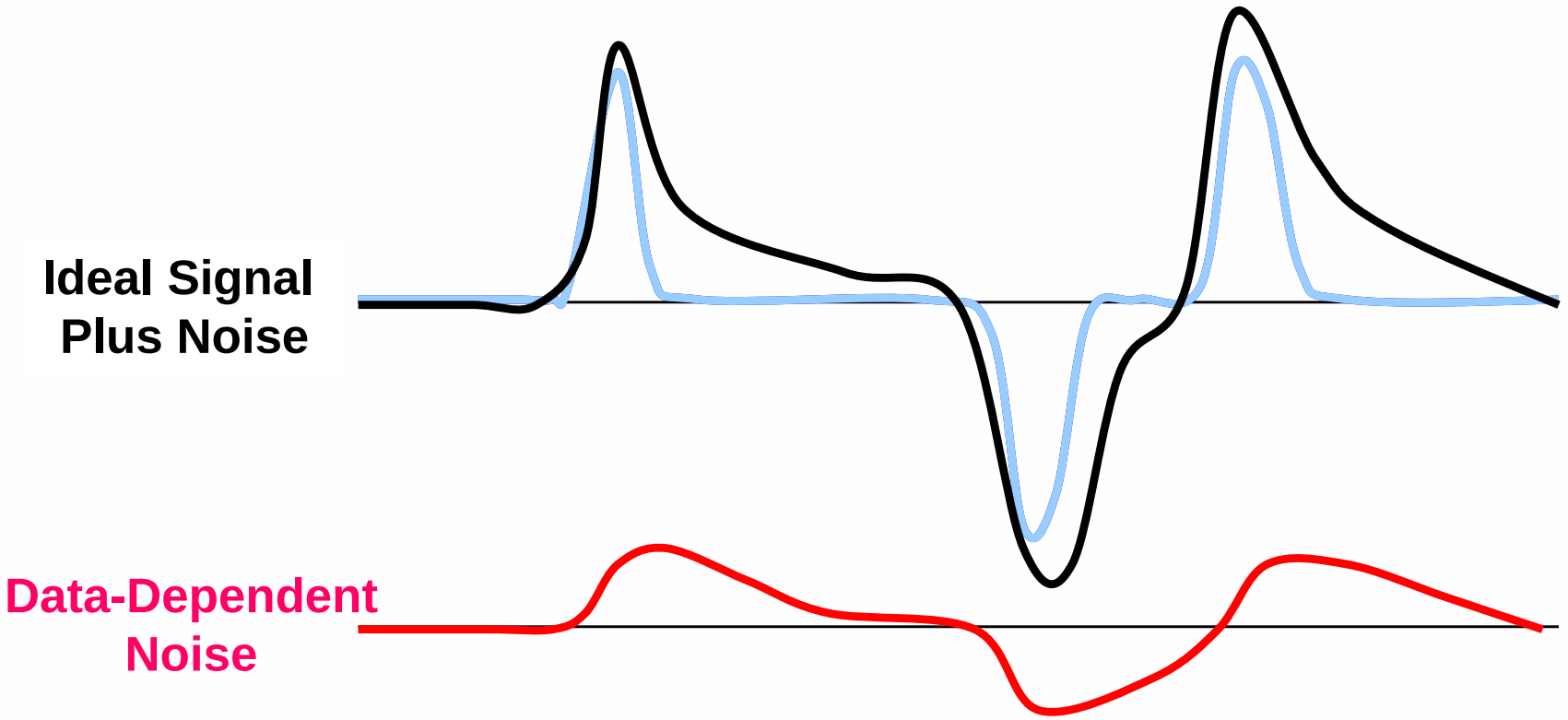

- Different types of noise may be present simultaneously

# White Noise




- Random noise is “white noise”

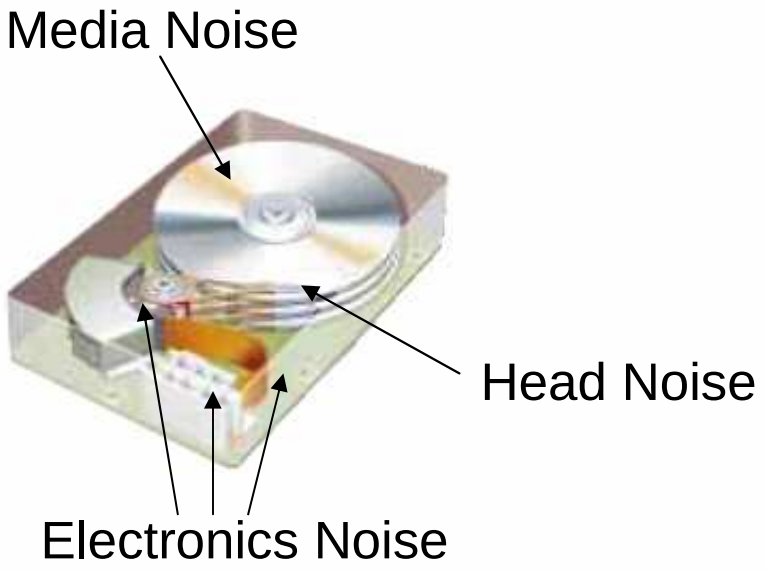
# Data-Dependent Noise




- Noise can be related to the signal

# Sources of Noise

- Media Noise
  - media nonlinearities
  - signal nonlinearities
  - inter-symbol interference
  - off-track interference
- Electronics Noise:
  - front-end equalizers
  - thermal noise
  - amplifier noise
- Head Noise:
  - head nonlinearities
  - head impedance




'839 Patent at 1:58-63;
Ashar, *Magnetic Disk Drive Technology* at 231 (1997)
[ Marvell Tutorial Exh. 5]